7. EVALUATION OF WATER SYSTEM IMPROVEMENTS

A. GENERAL

The primary responsibility of a domestic water purveyor is to provide its customers with a plentiful supply of high quality water. While meeting this primary responsibility, the purveyor also is expected to provide satisfactory service and operate the water system in a financially responsible manner. Within the water works industry, it is generally accepted that distribution facilities should be designed to provide an acceptable degree of reliability. The facilities also must maintain adequate residual pressures throughout the system while supplying maximum hour water use and a reasonable amount of water for fire fighting.

Based on the results of the hydraulic analyses conducted during this study, a long-range capital improvement program was established for the City of Bloomington Utilities. Various system configurations were evaluated to identify the configuration that was most appropriate for meeting current and projected water use. The resulting improvement plan is designed to keep pace with projected growth and provide a reliable base for future development.

The recommended water supply, treatment, and distribution system improvements shown on Figure 7-1 update and supersede the improvements recommended in our 1986 and 1993 reports. Some of the 1993 report improvements have been modified or deleted as a result of changes in projected growth patterns and water requirements and the moving of previously recommended improvements to more desirable locations.

It is recommended water works practice to provide water supply and treatment facilities with sufficient capacity to meet projected maximum day demands. Current projections indicate the maximum day demands will reach approximately 24 mgd by Year 2010 and 32 mgd by Year 2030. As discussed earlier in this report, the current rated capacity of its existing Monroe WTP is 24 mgd.

7. WATER SYSTEM ALTERNATIVES EVALUATION

During this study, three treatment expansion alternatives were evaluated to provide sufficient firm capacity to meet projected maximum day demands. The three plans that were identified and discussed in Chapter 6 – Hydraulic Analyses were as follows:

Alternative A – Expand the Monroe WTP from 24 to 36 mgd
Alternative B – Construct a new 12 mgd Dillman WTP
Alternative C – Construct a new 12 mgd North WTP

All of the plans are feasible from an engineering stand point and will meet CBU's projected short- and long-range water requirements.

B. POTENTIAL INCREASE IN WHOLESALE WATER USE

It should be recognized that the water use projections discussed in this report were based on supplying water to current and future customers within CBU's existing retail service area and on meeting current contractual requirements with existing wholesale customers. Although it is impossible to know for certain at this time, it is entirely possible that CBU's current wholesale customers may want to increase their contractual amounts in the future. The recommendations developed during this study will need to be reviewed and possibly modified to accommodate any significant future increases in wholesale water use.

Elletsville, Southern Monroe, and Van Buren Township appear to have the greatest potential need for additional water purchases from CBU. These customers are experiencing growth, and it is therefore conceivable that they may want to purchase additional water from CBU in the future. If one or more of the existing wholesale customers are to be provided significant additional water above that currently anticipated, CBU will be faced with the issue of how best to provide the additional finished water.

7. WATER SYSTEM ALTERNATIVES EVALUATION

With the exception of Elletsville, CBU supplies water to its wholesale customers at a maximum hour rate. Since Elletsville has several tanks in its system and the tanks are turned over regularly, CBU can supply water to the Town at the maximum day rate and the Town can meet the difference between the maximum hour and maximum day rates from their system storage. Southern Monroe, Washington Township, and B&B Water Project, Inc. also have storage tanks, but are supplied at the customers' required maximum hourly rate. As water use increases, CBU may be required to supply all of their wholesale customers at the customers' maximum day rates and require the customers to provide any additional maximum hour water needs from the customers' own system storage.

C. DISTRIBUTION MAINS

The distribution main improvements are shown on Figure 7-1 with a corresponding reference number. Current development patterns and growth expectations were reviewed and considered in developing these recommendations. Once installed, the improvements will provide the required capacity and reliability to meet projected water demands through the Year 2030. Many of the distribution mains listed below were identified by CBU for maintaining and improving its current distribution system, independent of growth and will be constructed in the next 5 years.

The following distribution improvements were included in the hydraulic analyses for each water treatment expansion alternative. The improvement number in parentheses corresponds with the reference number on Figure 7-1.

1. West Service Level

- **Knapp Road Main (Improvement No. 1).** A new 12-inch main connecting the 12-inch stub off of Vernal Pike to the 8-inch main along Knapp Road is needed to improve flow and pressures.

- **Tie Mains (Improvement No. 2).** Two 10-inch tie mains connecting the existing 20-inch main along Park Square Drive are needed.

2. Central Service Level

- **Grant Street Main (Improvement No. 3).** A new 24-inch main along Grant Street between East 3rd Street and West Allen Street is needed to improve flow and pressures.

- **Allen Street Main (Improvement No. 4).** A new 12-inch main along Allen Street connecting the 24-inch mains along Walnut and Rogers Streets is needed to improve flow and pressures.

- **South Patterson Drive Main (Improvement No. 5).** A new 12-inch main is needed to replace the existing 16-inch main between 3rd and 2nd Streets.

- **Adams Street Main (Improvement No. 6).** A new 12-inch main is needed along Adams Street between Allen Street and Tapp Road.

- **Kinser Pike Main (Improvement No. 7).** A new 12-inch extension to Acuff and Prow Roads is needed.

- **Indiana Avenue Main (Improvement No. 8).** A new 20-inch main is needed along Indiana Avenue between 3rd and 10th Streets to improve flow and pressures.

- **Indiana Avenue Main (Improvement No. 9).** A new 16-inch main is needed along Indiana Avenue between 10th and 17th Streets to improve flow and pressures.

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- **10th Street Main (Improvement No. 10).** A new 16-inch main is needed between Dunn Street and Forrest Avenue to improve flow and pressures.

- **10th Street Main (Improvement No. 11).** A new 12-inch main is needed between Forrest Avenue and Fee Lane.

- **East Tank Altitude Valve (Improvement No. 12).** A new altitude valve should be installed on the East tank to prevent overflowing when the Redbud tank is replenishing (for Alternative A only).

- **Redbud Tank Altitude Valve (Improvement No. 13).** A new altitude valve should be installed on the Redbud tank to prevent overflowing when the East tank is replenishing (for Alternative C only).

- **Walnut Street Main (Improvement No. 14).** A new 24-inch main along Walnut Street, from Stonemill Road and Old State Route 37 to the existing 24-inch main along 20th Street, is needed only if the 12 mgd North WTP (Alternative C) is expanded to 24 mgd.

7. WATER SYSTEM ALTERNATIVES EVALUATION

Fig 7-1

7. WATER SYSTEM ALTERNATIVES EVALUATION

D. EVALUATION OF ALTERNATIVE PLANS

To meet future water requirements, CBU will need to either expand its Monroe WTP from 24 mgd to 36 mgd (Alternative A) or construct either a new 12 mgd Dillman (Alternative B) or North (Alternative C) water treatment facility. From an economic standpoint, it may be favorable to expand the Monroe WTP, however, from a security standpoint, constructing the Dillman or North facility would be preferable. From a hydraulic standpoint, Alternative C provides the benefit of serving customers from the north.

The following discusses the improvements required for each alternative. The improvements were based on the results of the hydraulic modeling, the advantages and disadvantages, the required treatment processes, as well as the implementation requirements and project schedule discussed below.

1. Alternative A – Expand Monroe WTP from 24 mgd to 36 mgd. Expand the 24 mgd Monroe WTP to a capacity of 36 mgd and replace the existing conventional gravity filters with a 36 mgd submerged-type membrane filtration system. This alternative would require a parallel 30-inch raw water line to be installed from the intake to the plant and a parallel 36-inch finished water transmission main from the plant to the proposed 30-inch Southeast main that would connect to the existing 36-inch transmission main near Harrell Road and Moffat Lane. This alternative also includes the proposed 30-inch Southeast main along Harrell Road; a new Southeast pump station and tank located near Harrell and Rhorer Roads; a 36-inch main along Rhorer to Sare Road; a 24-inch North branch main along Sare Road to the existing 24-inch main in Moores Pike and a 24-inch West branch main along Rhorer Road, then north along South Rogers Street to West Country Club Drive, then west along Country Club Drive to connect to the two existing 24-inch mains at the intersection of Rockport and West Tapp Roads.

7. WATER SYSTEM ALTERNATIVES EVALUATION

a. Advantages

- The proposed Southeast transmission main will provide redundancy to the existing 36-inch transmission main from the Monroe WTP to the South Tanks.
- If a break should occur in one of the two finished water transmission mains, CBU can continue to provide up to 24 mgd to the distribution system.
- The proposed Southeast pump station would provide water to the Central service level if the South-Central pump station is off-line or if there is a break in the existing 36-inch transmission main serving the South-Central pump station.
- Lake Monroe is used, which has an abundant supply of good quality raw water.
- There is familiarity with the water supply.
- Expanding the Monroe WTP is the most economical of the three alternatives.

b. Disadvantages

- It does not provide an independent second water source.
- The Monroe WTP cannot be easily expanded past 36 mgd.

c. Required Treatment Processes

The Lake Monroe water quality for the Year 2002 is presented in Table 7-1.

7. WATER SYSTEM ALTERNATIVES EVALUATION

Table 7-1
2002 Lake Monroe Water Quality Data

Constituent	Average	Range
Alkalinity	27.3	20-38
Total Hardness	46.4	24-62
Turbidity	7.6	2.6-22.0
pH	7.3	6.1-7.8
a. All values in mg/L as $CaCO_3$ except pH, Turbidity in NTUs.		

The design objective for the Monroe WTP is to provide economical and efficient water treatment that will:

- Achieve finished water turbidities consistently below 0.1 NTU.
- Maintain TTHM and HAA5 concentrations at less than 0.08 mg/L and 0.06 mg/L, respectively, throughout the CBU distribution system.
- Incorporate a process to inactivate or remove *Cryptosporidium* oocysts.

The following treatment processes are available for obtaining the design treatment objectives:

- Turbidity Removal

  Fine particles, such as organic solids, viruses, bacteria, algae, and other substances that scatter light in the drinking water cause turbidity. By definition, turbidity is the measure of the scattered light from a controlled source measured at 90 degrees to the path of light. MF/UF membranes are capable of high particle removal rates due to their ability to provide an absolute barrier to particles and other constituents larger than their pore size.

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Since MF/UF membranes are capable of removing turbidity, particles, and total suspended solids, water can be treated using such membranes.

The use of membrane filters as an alternative to conventional gravity media filters is proposed based on the demonstrated ability to achieve high levels of suspended solids/turbidity removal. MF and UF membranes are physical processes in which particles larger than 0.1 microns for microfiltration and larger than 0.01 microns for ultrafiltration are removed from the water by straining through a porous medium. The membrane filtration processes provide exceptional removal of turbidity and can produce treated water with turbidities of less than 0.10 NTU. Since MF/UF membranes are capable of removing turbidity, particles, and total suspended solids, as demonstrated in the 2002 Membrane Filtration Pilot Study, the water will be treated with these membranes.

- Disinfectant Byproduct Removal

Although a disinfectant (free chlorine) residual is required, it is recognized that an excessive amount of disinfectant residual may pose a threat to health as well as contribute to increased formation of undesirable disinfection byproducts. The precursors of disinfection byproduct formation are naturally occurring organic substances. When combined with any of the disinfectants, DBPs will form. To meet regulations, CBU must maintain TTHM and HAA5 concentrations throughout the distribution system at less than 0.08 mg/L and 0.06 mg/L, respectively. Since MF/UF membranes are capable of removing some of the DBP precursors, as demonstrated in the 2002 Membrane Filtration Pilot Study, the water will be treated with these membranes.

- *Cryptosporidium* Removal

Systems treating surface water and serving more than 10,000 consumers must achieve at least a 2-log (99%) removal of *Cryptosporidium*. Research

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and outbreaks of water-borne diseases have shown that certain viruses and bacteria, such as *Cryptosporidium* resist conventional treatment. Therefore, alternate treatment technologies are desirable. As the pore sizes are significantly smaller than *Cryptosporidium* oocysts (2 to 5 microns), MF/UF membranes provide excellent removal of these microbial contaminants. MF/UF is an alternate treatment technology that will improve the control of microbial pathogens in the drinking water, particularly *Cryptosporidium*.

In addition to the existing treatment components, a flocculation/sedimentation basin with plate settlers and MF/UF membranes are proposed for Alternative A.

Sodium hypochlorite and sodium hydroxide, which will be installed as part of another project, will be added at the finished water reservoir influent. The reservoir will be baffled to achieve adequate CT. Sodium hypochlorite and aqueous ammonia will be added at the finished water reservoir effluent to maintain the needed residual in the distribution system.

A schematic showing the proposed treatment processes for this alternative is shown on Figure 7-2.

7. WATER SYSTEM ALTERNATIVES EVALUATION

Fig 7-2

7. WATER SYSTEM ALTERNATIVES EVALUATION

2. Alternative B – New 12 mgd Dillman WTP. Construct a 12 mgd membrane filtration water treatment plant that is expandable to 24 mgd, adjacent to the Dillman Wastewater Treatment Plant (WWTP), near Dillman Road and Victor Pike. Raw water would be conveyed through a 36-inch transmission main from a new intake located near the Indiana Department of Natural Resources (IDNR) site on Lake Monroe. From the Dillman WTP's high service pumps, finished water would be conveyed through a 36-inch transmission main into two 24-inch Central service level mains at Rockport and Tapp Roads and a 16-inch main along West Country Club Drive between Rockport Road and South Old SR 37. This alternative also includes retrofitting the Monroe WTP with a 24 mgd submerged-type membrane filtration system installed in the existing conventional gravity filter boxes to provide the same high quality water as the new Dillman WTP.

a. Advantages.

- The intake facility can be expanded easily to a capacity of 24 mgd.
- Residuals can be pumped to the Dillman WWTP for processing, thereby eliminating the need for a residuals dewatering facility.
- Treated water would be pumped directly into the Central service level, thereby eliminating the need for the Fullerton pump station and tank previously proposed by CBU.
- Provides 12 mgd of treated water to the system in the event that the Monroe WTP or intake is off-line or if there is a break in the existing 36-inch finished water transmission main.
- Having two separate withdrawal locations on Lake Monroe provides a greater level of security than with a single supply and treatment facility.

- Lake Monroe is used, which has an abundant supply of good quality raw water.

- There is familiarity with the water supply.

b. Disadvantages

- Increases O&M costs by having a second water treatment plant and staff.

- Has high capital cost.

c. Required Treatment Processes

The Dillman WTP will treat water from Lake Monroe, the quality of which was identified earlier in this chapter. The design objective for the Dillman WTP is to provide economical and efficient water treatment that will:

- Achieve finished water turbidities consistently below 0.1 NTU.

- Maintain TTHM and HAA5 concentrations at less than 0.08 mg/L and 0.06 mg/L, respectively, throughout the CBU distribution system.

- Incorporate a process to inactivate or remove *Cryptosporidium* oocysts.

- Develop a layout that offers future ease of expansion.

The treatment processes available for obtaining the design treatment objectives are as described earlier for Alternative A. The proposed treatment components for Alternative B consist of a raw water intake, pump station, rapid mix, flocculation/sedimentation, MF/UF membranes, and a finished water reservoir. Some of the MF/UF waste could be recovered with a small packaged treatment system, which would include coagulant and polymer addition and plate settlers. The effluent would be returned to the head of the main plant.

Sodium hypochlorite, sodium hydroxide, and fluoride will be added at the finished water reservoir influent. The reservoir will be baffled to achieve adequate CT. Sodium hypochlorite and aqueous ammonia will be added at the finished water reservoir effluent to maintain the needed residual in the distribution system.

The proposed intake and raw water pump station should be sized for 24 mgd so the future pumps and associated valves, piping, electrical and instrumentation can be installed when additional capacity is needed.

A schematic showing the proposed treatment processes for Alternative B is shown on Figure 7-3.

7. WATER SYSTEM ALTERNATIVES EVALUATION

Fig 7-3

7. WATER SYSTEM ALTERNATIVES EVALUATION

3. Alternative C – New 12 mgd North WTP Using Groundwater Supply. Construct a 12 mgd North membrane filtration water treatment plant that is expandable to 24 mgd, near Bottom Road and State Route 37 or adjacent to the Blucher Poole WWTP. Groundwater from a collector well, located approximately 12 miles north of Bloomington near the confluence of the White River and Bean Blossom Creek, would be conveyed through a 36-inch transmission main to the new plant. The plant will treat the water using membrane filtration for solids removal and reverse osmosis for softening. Another consultant has already completed a preliminary study for CBU that evaluated using a groundwater supply. The water supply has not been classified as strictly groundwater or as under the direct influence of surface water at this time. If the water supply to the North is considered to be strictly groundwater, using MF/UF membranes prior to RO membranes would not be recommended from an economical standpoint; oxidation of any iron and manganese followed by conventional gravity media filters would be recommended in lieu of the MF/UF membranes. From the new North plant, finished water would be conveyed through a 36-inch transmission main to the Central service level mains near Stonemill Road and Old State Route 37. If the North plant is expanded to 24 mgd, then the 36-inch main should be extended as a 24-inch main along Walnut Street to the existing 24-inch main on 20th Street. Alternative C also includes retrofitting the Monroe WTP with a 24 mgd submerged-type membrane filtration system to provide the same high quality water as the new North WTP.

a. Advantages

- The water supply is independent of Lake Monroe, and provides a greater level of security as compared to a single supply and treatment facility.

- Provides 12 mgd of treated water to the system in the event that the Monroe WTP or intake is off-line or if there is a break in the existing 36-inch finished water transmission main.

- Less pumping head is required conveying water to the northern extremities of the distribution system from the proposed North WTP than from the existing Monroe or proposed Dillman WTP.

- Residuals can be pumped to the Blucher Poole WWTP for processing, thereby eliminating the need for a residuals dewatering facility.

b. Disadvantages

- Increases O&M costs by having a second water treatment plant and staff.

- Requires a new collector well and associated piping to expand the plant to 24 mgd.

- Has water quality compatibility concerns related to the mix of treated surface water and groundwater.

- Has high capital cost.

c. Required Treatment Processes

As available data are limited on the groundwater quality in the area near the confluence of the White River and Bean Blossom Creek, a conservative approach was used to develop probable treatment facility requirements. Before treatment processes can be finalized, additional water quality data will need to be collected and reviewed. The classification of the groundwater also will need to be determined since treatment requirements are different depending on whether the groundwater is considered under the influence of surface water or strictly groundwater. If the water source is classified as a groundwater supply, the provisions of the SWTR will not apply. If the water source is classified as under the influence of surface water, the principal implications would be in the monitoring and disinfection aspects of the SWTR. It is anticipated that the raw water will be considered a groundwater source not under the influence of surface water.

Preliminary data, as presented in another consultant's study, and listed in Table 7-2, was utilized to make initial evaluations of the groundwater quality in the area and possible treatment schemes. The water is quite hard and requires softening as well as iron and manganese removal.

Table 7-2
Groundwater Quality Data

Constituent	Concentration[a,b]
Alkalinity	241
Total Hardness	385
Iron	1.80
Manganese	0.22
Fluoride	0.28
pH	7.2
Turbidity	0.20

a. Values shown are for groundwater not under the direct influence of surface water.
b. All values in mg/L except pH, Turbidity in NTUs.

The design objective for the North WTP is to provide economical and efficient water treatment that will:

- Reduce iron and manganese concentrations to below 0.3 mg/L and 0.05 mg/L, respectively.
- Reduce total hardness of the finished water to 150 mg/L as $CaCO_3$.
- Achieve finished water turbidities consistently below 0.1 NTU.

- Maintain TTHM and HAA5 concentrations at less than 0.08 mg/L and 0.06 mg/L, respectively, throughout the CBU distribution system.

- Incorporate a process to inactivate or remove *Cryptosporidium* oocysts, if the groundwater is under the influence of surface water.

- Stabilize the finished groundwater to prevent corrosive conditions and the precipitation or dissolution of existing deposits when mixed with finished surface water in the CBU distribution system.

- Develop a layout that offers future ease of expansion.

The following treatment processes are available for obtaining the design treatment objectives:

- Iron and Manganese Removal

  Iron and manganese are commonly found in well water supplies and are generally attributed to the solution of rocks and minerals; chiefly metal oxides, sulfides, carbonates, and silicates. To avoid stains in laundry and on plumbing fixtures, iron concentrations should be less than 0.3 mg/L and manganese concentrations should be less than 0.05 mg/L.

  There are several methods available to remove iron and manganese in public water supplies. They can be removed by:

  1. Aeration, Chemical Oxidation, and Filtration (Gravity Filters Equipped with “Synthetic” Greensand, Microfiltration (MF), or Ultrafiltration (UF)).

     The raw water is aerated, thereby oxidizing the soluble iron and manganese and converting them to insoluble compounds. Potassium permanganate is added after aeration to speed the manganese reactions, which are otherwise very slow. Nearly all of the iron and manganese reactions will be completed during a typical 30 minute retention process. If aeration is not used, oxidation can be accomplished by using chemicals only. The precipitates of iron and manganese that form can then be removed by a filtration process. Gravity filters equipped with "synthetic" greensand media or MF/UF membranes can physically remove the oxidized iron and manganese. "Synthetic" greensand filters use a base material, comprised of sand or anthracite, coated with manganese oxide and remove any residual soluble manganese.

2. Removal in Conjunction with Lime-Soda Softening.

   Lime-soda softening is a process of removing carbonate and non-carbonate hardness by the addition of lime for carbonate hardness removal; and soda ash, or lime plus soda ash for the removal of non-carbonate hardness. The primary purpose of the lime-soda softening process is to remove calcium and magnesium hardness. When the alkalinity of the raw water is raised to precipitate the calcium and magnesium, iron and manganese are converted to insoluble iron and manganese hydroxide precipitates and are removed by sedimentation and filtration.

- Hardness Removal

  Water hardness is a measure of the dissolved calcium and magnesium compounds in the water. There are two types of hardness, carbonate and noncarbonate. Carbonate hardness is caused by the carbonates and bicarbonates of calcium and magnesium. Noncarbonate hardness is caused by the nitrates, chlorides, and sulfates of calcium and magnesium. MF/UF membranes cannot remove dissolved hardness.

The total hardness will be reduced to 150 mg/L as $CaCO_3$. Although the hardness will be greater than that leaving the Monroe WTP (65 mg/L as $CaCO_3$), 150 mg/L is more economically feasible and should be acceptable to the users.

Some common methods of softening include:

1. Reverse Osmosis (RO) Membranes

   RO membranes have a pore size typically less than 0.001 microns and can remove particles down to ion size, including the molecules that cause hardness. This softens the water. It is not necessary to treat all the water leaving filtration (MF/UF membranes or conventional gravity media filters) with RO membranes. To obtain a desired finished water hardness of 150 mg/L, approximately 30% of the MF/UF filtered water would bypass the reverse osmosis membranes and then be blended with the softened water to achieve the 150 mg/L hardness goal. Bypassing less flow could proportionately reduce the finished water hardness, but would affect the amount of RO membranes needed. This process could be automated to function with little operator intervention; however, this process would be more costly than conventional softening processes.

2. Ion Exchange Softening

   In ion exchange softening, two sodium ions are put into solution for each calcium or magnesium ion that is removed. The process uses an exchange resin to replace the calcium and magnesium ions with sodium ions, thereby softening the water. Once the resin exchange capacity has been exhausted, it must be regenerated using a sodium chloride (salt) solution. Disposal of the removed calcium and magnesium chloride from regeneration can be and may become more problematic as regulations on discharges become more stringent. The process is typically more economical and more easily operated than lime-soda softening.

3. Lime-Soda Softening

Lime-soda softening adds alkalinity to the water to precipitate hardness causing calcium and magnesium compounds. Lime alone is used to precipitate carbonate hardness. Soda ash, soda ash and lime, or caustic soda (sodium hydroxide) are used to precipitate noncarbonate hardness. The effluent from the lime-soda process is typically caustic and high in pH. The water contains calcium hydroxide, which must be converted to calcium carbonate and then to calcium bicarbonate to stabilize the water. This neutralization process is accomplished by recarbonation, typically through the addition of carbon dioxide. Lime-soda softening requires more operator attention and is not easy to automate.

- Turbidity Removal

Fine particles, such as organic solids, viruses, bacteria, algae, and other substances that scatter light in the drinking water cause turbidity. By definition, turbidity is the measure of the scattered light from a controlled source measured at 90 degrees to the path of light. Conventional gravity media filters or MF/UF membranes could be used to remove turbidity. MF/UF membranes are capable of high particle removal rates due to their ability to provide an absolute barrier to particles and other constituents larger than their pore size. Since MF/UF membranes are capable of removing turbidity, particles, and total suspended solids, water can be treated using such membranes.

If the groundwater is classified as under the influence of surface water, it is recommended that MF/UF membranes be implemented. If the water source

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is determined to be “strictly” groundwater, then conventional gravity media filtration would be appropriate.

- Disinfectant Byproduct Removal

  Although a disinfectant (free chlorine) residual is required, it is recognized that an excessive amount of disinfectant residual may pose a threat to health as well as contribute to increased formation of undesirable disinfection byproducts. The precursors of disinfection byproduct formation are naturally occurring organic substances. When combined with any of the disinfectants, DBPs will form. To meet regulations, CBU must maintain TTHM and HAA5 concentrations throughout the distribution system at less than 0.08 mg/L and 0.06 mg/L, respectively. Since MF/UF membranes have been found to be capable of removing some of the DBP precursors, their use should be considered.

- *Cryptosporidium* Removal

  Systems treating surface water or groundwater under the direct influence of surface water and serving more than 10,000 consumers must achieve at least a 2-log (99%) removal of *Cryptosporidium*. Research and outbreaks of water-borne diseases have shown that certain viruses and bacteria, such as *Cryptosporidium* resist conventional treatment. Therefore, alternate treatment technologies are desirable. MF/UF membranes are a physical process in which particles larger than 0.1 microns for microfiltration and larger than 0.01 microns for ultrafiltration are removed from the water by straining through a porous medium. As these pore sizes are significantly smaller than *Cryptosporidium* oocysts (2 to 5 microns), MF/UF membranes provide excellent removal of these microbial contaminants. MF/UF is an alternate treatment technology that will improve the control of microbial pathogens in the drinking water, particularly *Cryptosporidium*.

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If the groundwater is classified under the direct influence of surface water, the proposed treatment components for Alternative C consist of a collector well, pump station, MF/UF membranes, reverse osmosis membranes, and a finished water reservoir. If the water source is determined to be “strictly” groundwater, then conventional gravity media filtration could be implemented in lieu of MF/UF membranes.

CBU has expressed interest in softening the water using reverse osmosis as well as having an automated plant. Conventional filtration, membrane filtration, and reverse osmosis can be easily automated. Thus, either conventional filtration or membrane filtration, and reverse osmosis for softening have been proposed.

Sodium hypochlorite, sodium hydroxide, and fluoride will be added at the finished water reservoir influent. The finished water reservoir will be baffled to achieve adequate CT. Sodium hypochlorite and aqueous ammonia will be added at the finished water reservoir effluent to maintain the needed residual in the distribution system.

The RO waste cannot be recovered with a small packaged treatment system, like Alternative B, very cheaply. The only means of recovering the waste include a thermal process, essentially distillation, and that would be uneconomical. The RO waste would be discharged to a nearby sewer for treatment at the Blucher Poole WWTP.

If the North WTP is expanded in the future, another collector well will need to be constructed.

A schematic showing the proposed treatment processes for Alternative C is shown on Figure 7-4.

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Fig 7-4

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4. Option to Alternative C – New 12 mgd North WTP Using Surface Water Supply (Lake Lemon, Bean Blossom Creek, and Griffy Lake). Construct a new 12 mgd North water treatment plant, near State Route 37 and Bean Blossom Creek. Surface water from Lake Lemon, Bean Blossom Creek, and Griffy Lake will be treated using MF/UF membrane filtration. This option also includes retrofitting the Monroe WTP with a 24 mgd submerged-type MF/UF membrane filtration system to provide the same high quality water as the new North WTP.

a. Advantages

- Water supply is independent from Lake Monroe, which provides a greater level of security as compared to a single supply and treatment facility.

- Provides 12 mgd of treated water to the system in the event that the Monroe WTP or intake is off-line or if there is a break in the existing 36-inch finished water transmission main.

- Less pumping head is required conveying water to the northern extremities of the distribution system from the proposed North WTP than from the existing Monroe or proposed Dillman WTP.

- Residuals can be pumped to the Blucher Poole WWTP for processing, thereby eliminating the need for a residuals dewatering facility.

b. Disadvantages

- The water source likely does not have sufficient yield to support expansion of the proposed 12 mgd plant in the future without other sources to supplement the North supply.

- Increases O&M costs by having a second water treatment plant and staff.

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c. Required Treatment Processes

Water quality data for the proposed raw water sources were reviewed to identify constituents that would affect the treatment of the water for domestic use. Since water quality data are not available at this time, it was assumed that the water quality was the same as that presented in the 1986 Capital Improvement Plan Report and as listed in Table 7-3. Before treatment processes can be finalized, water quality data will need to be collected and reviewed. The hardness concentration of the combined raw water to the North facility is expected to be acceptable, so no softening is anticipated. In the event that the surface water supply is supplemented with groundwater, it is likely that softening will be required. Therefore, provisions for adding RO membranes should be addressed during the design of the facility.

Table 7-3
1986 Lake Lemon, Bean Blossom Creek, and Griffy Lake Water Quality Data

	Lake Lemon		Bean Blossom Creek		Griffy Lake	
Constituent	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**
Alkalinity	44	36-56	48	38-56	95	92-100
Total Hardness	97	83-113	114	89-135	248	222-298
Calcium	28	24-34	34	26-43	88	77-108
Magnesium	6.3	5.8-6.7	6.7	6.0-7.1	7.0	7.0-7.1
Iron	1.5	1.3-1.6	1.4	0.7-2.0	1.0	0.3-2.0
Manganese	0.10	0.07-0.14	0.13	0.0-0.24	0.08	0.04-0.14
Chloride	7	2-9	6	1-9	6	1-9
Sulfate	34	26-43	28	21-235	25	25-26
Fluoride	0.12	0.11-0.13	0.11	0.08-0.13	0.12	0.10-0.13
Total Dissolved Solids	128	114-154	124	98-158	179	176-184
Turbidity	15	12-18	17	14-20	14	5-23
pH	7.3	6.9-7.6	7.4	7.2-7.5	7.3	6.9-7.6
a. All values in mg/L except pH, Turbidity in NTUs.						

7. WATER SYSTEM ALTERNATIVES EVALUATION

The design objective for the North WTP using a surface water supply is to provide economical and efficient water treatment that will:

- Reduce iron and manganese concentrations to below 0.3 mg/L and 0.05 mg/L, respectively.
- Reduce total hardness of the finished water to 150 mg/L as $CaCO_3$.
- Achieve finished water turbidities consistently below of 0.1 NTU.
- Maintain TTHM and HAA5 concentrations at less than 0.08 mg/L and 0.06 mg/L, respectively, throughout the CBU distribution system.
- Incorporate a process to inactivate or remove *Cryptosporidium* oocysts.
- Develop a layout that offers future ease of expansion.

The treatment processes available for obtaining the design treatment objectives are as described earlier for Alternative C. The proposed treatment components for the surface water supply consist of an intake/pump station, rapid mix, flocculation/sedimentation, MF/UF membranes, and a finished water reservoir.

Sodium hypochlorite and potassium permanganate will be used to oxidize iron and manganese. Sodium hypochlorite, sodium hydroxide, and fluoride will be added at the finished water reservoir influent. The reservoir will be baffled to achieve adequate CT. Sodium hypochlorite and aqueous ammonia will be added at the finished water reservoir effluent to maintain the needed residual in the distribution system.

7. WATER SYSTEM ALTERNATIVES EVALUATION

E. FUTURE REGULATORY CONSIDERATIONS

The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is intended to protect the public health from excessive exposure to *Cryptosporidium* and applies to all systems that use surface water or groundwater under the influence of surface water. *Cryptosporidium* is very small and chemically resistant and therefore difficult to capture, destroy, or inactivate. The Rule incorporates system specific treatment requirements based on source water *Cryptosporidium* monitoring. Stage 2 of the Rule may require additional treatment, such as ozone, chlorine dioxide, ultraviolet (UV) irradiation, membranes, bag/cartridge filters, or in-bank filtration, depending on monitoring results. It is anticipated that Stage 2 of the Rule takes effect by 2008.

CBU has expressed a strong interest in using membranes to comply with future turbidity requirements, possible *Cryptosporidium* removal requirements and to provide high quality water to its customers. Membranes provide a positive barrier to Cryptosporidium and are a strong candidate for use, especially at a new water treatment plant. Since the Monroe WTP is presently in compliance with finished water turbidity requirements, CBU should consider evaluating UV for *Cryptosporidium* inactivation at the Monroe WTP before making a final decision to implement membranes. UV testing on a pilot-scale would be required before any decision could be made on full-scale implementation. If UV was implemented and the Monroe WTP expanded in capacity, additional gravity media filters would be required. Because either 24 mgd or 36 mgd of membranes would need to be installed at the Monroe WTP, it is likely that an expansion using conventional gravity media filters and implementation of UV for *Cryptosporidium* inactivation would be more economical than membrane filtration.

UV disinfection has proven to be effective at inactivating *Cryptosporidium*. Ultraviolet light penetrates the bacteria’s cell wall and alters the genetic makeup, DNA, and renders the bacteria incapable of replication and terminates its life cycle. UV disinfection is a relatively low-cost technology.

The advantages of UV include:

- Lower costs than for comparable microbial control process (ozone or microfiltration);
- Requires little space and can usually be easily incorporated into existing plants;
- Does not produce any known toxic or significant nontoxic byproducts.

F. WATER SYSTEM IMPROVEMENTS SCHEDULE

The maximum day water demands are projected to be 24 mgd by 2010 as discussed in Chapter 3, Water Requirements. Therefore, the 2010 maximum day water demand is expected to exceed the capacity of the Monroe WTP. As water treatment plants are typically sized to provide maximum day water demands, it is recommended that the water system improvements be completed and operational in the Year 2008.

To ensure ample time, CBU should allow 30 months for construction and start-up of the new facilities. In addition, approximately 20 months should be allowed for preliminary design; detailed design; obtain all permits and approvals; acquire all necessary land and easements; accept bids; and award the construction contract. Thus the total time from beginning of the preliminary design through construction is estimated to be 50 months. A schedule indicating the major project milestones is shown in Table 7-4.

7. WATER SYSTEM ALTERNATIVES EVALUATION

As this capital improvements program represents an important and critical decision on the direction of the water utility, it is paramount to include the public in the selection of the alternatives described herein. The schedule allows several months for obtaining input and comments through public meetings prior to making a decision and proceeding with the capital improvements program.

7. WATER SYSTEM ALTERNATIVES EVALUATION

Table 7-4